An efficient vehicles navigation methodology using dyna changes in local maps

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Index Terms:
driver information systems; Global Positioning System; radionavigation; senso road vehicles; vehicles navigation; dynamic local maps; real traffic environmen fusion; GPS coordinates; continuous transmission; road vehicles

AN EFFICIENT VEHICLES NAVIGATION METHODOLOGY USING DYNAMIC CHANGES IN LOCAL MAPS

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Abstract

In this paper an efficient, low cost car's navigation methodology is presented, by taking into account the dynamic changes that occur in real traffic environments. The methodology proposed here is based on the fusion of local maps and additional region information (broadcasted by a station) and the GPS coordinates. It is known that one of the serious problems that future car-drivers will face is the insufficient information provided by CD-ROMs. More specifically, the CD-ROMs will not able to include in their databases information related with the current status of the traffic delays, construction, detours, accidents, traffic readjustments, etc occurred in several geographic regions. The solution of this type of problems is the use continuous transmission of the local maps, which include all the current changes at a certain region, via a radio or TV station. A navigation system built in a vehicle will receive the local maps and will fuse in them the GPS coordinates in order to locate the vehicle, as light spot, on the map. This approach provides to the driver several choices and sufficient information for a safe, convenient travel. It will also save lives in case of accidents and traffic delays.

A patent has been filed for this work.

1. Introduction

Navigation has been an interesting problem to be perfected for a long time. The current stage of navigation for land vehicles fundamentally include static digital map(s) and vehicle positioning, plus some secondary additional features, such as route guidance, en-route driver information, etc. Some proposed or implemented systems, which attempt to solve this problem above, use CD-ROM or PCMCIA cards by providing to the car's system a digital map, and for the car's positioning they used dead reckoning and later the commercialized global positioning system (GPS). SONY Electronics MVX-F160 mobile navigation system utilizes the global positioning system in combination with digital maps on CD-ROM developed by Etak Inc [2]. It also includes information from Fodor Travel Guide on restaurants, hotels, stores and places of entertainment. In Florida, more specifically in Orlando area, Trav Tek devices picked up satellite signals, and emitted audible cues to guide motorist[3]. In addition , such systems allow to drivers to input a destination point and view the routes on the screens, that display digital maps form a CD-ROM. Using static digital maps from a CD-ROM or a PCMCIA card does not allow to the car's system to deal with minutes-by-minutes or even day-by-day dynamic changes occurred on the routes and traffic.

Accidents, constructions, and other traffic obstructions cause significant traffic delay and produce inconvenience and life's risks to travelers. For example, on May 24, 1995 in Philadelphia, there was an accident that involved a truck carrying hazardous material, the highway 476 had to be closed for more than 10 hours. During that time, the traffic jumped to the highest level, and most of the secondary roads were packed with vehicles trapped in the traffic jam, and more vehicles arrived, and got trapped there. The information, broadcasted through radio stations were not enough to detour most of the vehicles. One life were lost due to heart attack and many people suffered other kind of health problems in

that traffic jam. This event presents the size of and the importance of the problems that people faces every day near big sites, thus new effective research on the navigation systems have to done.

A unique solution to the problem above, proposed by this paper. The solution includes the use of dynamic local digital maps in conjunction with a navigation system employing GPS, and dead reckoning (odometer and magnetic compass) for vehicle positioning. More specifically the proposed system employs local digital maps broadcasted by a local radio/TV station by providing to the car's navigation system with an up to date (up to the minute) digital local map and information including route, traffic and other travel related information. This broadcasted digital map along with its information give the driver a current availability of the route, the statistic of the traffic, and up to date information of travel related places, and help the system to select optimum road according to the current conditions. These broadcasted local digital maps are updated in real time by the station operators, to include the most current information.

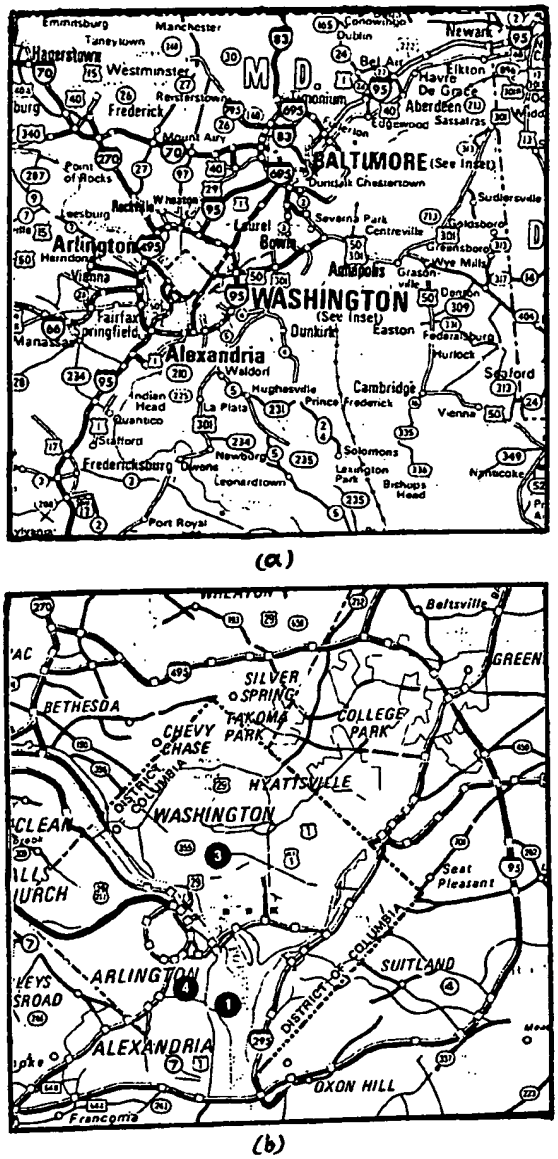
The car's navigation system, which receives local maps, will update its database (map and information) periodically to keep up with the most current information available. The computer in the navigation unit make the appropriate fusion between the local digital map and the position obtained from GPS and dead reckoning. Thus, the passengers know enough about where they are, which route they are taking, alternative routes, and the statistic of the traffic for each route and other information related to the routes, in order to make the best decision about their travel.

This paper presents the local map and GPS coordinates fusion methodology and the navigation system's characteristics at a feasibility level.

2. Methodology and System

2.1. The Generation and Broadcasting Local Digital Maps

The generation of every local map is based on accurate hierarchical representation of the map of a particular region, figure 1. More specifically, several images of a selected geographic region are taken by using camera, and then the corresponding digital maps are generated from these images, plus important information related with that region is added. Each local digital map is associated with a set of important information related to the traffic



Figurel:Two views of the same region.
a) Global view of Washington
b) Laoal view of Washington

and traffic statistics. These information includes current accidents, closed routes, statistical traffic information of the routes, congestion, constructions, and landmarks such as hospitals, rest areas, gas stations, police stations, etc.

In case that a congestion occurs on a road due to an accident, construction or other causes, in a certain route in a particular area, the operator at the radio or TV the station will be informed, thus the operator can up-date the local digital map with new information (up-date the value of statistic data of the congested route and the routes that are affected). Several suggested alternative routes can also be included to the broadcasted information to lighten the navigation system's selection of a detoured route. It is up to the user (car driver) whether to use this information or not. Now, if a congestion occurs in a route that was selected by a car driver, the route color will change, from blue to yellow, for congestion or red for closed traffic, and several alternative routes will be displayed with green lines. It is up to the driver to chose which routes to follow. When the navigation system detects the change of route, (from the current position of the vehicle) all of the green lines will disappear, and the taken route will change its color to blue. Of course the driver can also choose to stay in the congested route if he/she wants, in this case no change in color will occur, all of the yellow, and green lines stay.

If there are more than one map stations accessible by the car's receiver, the user can choose which station to be used, see figure 2. If the local map broadcasted by a certain station does not cover the current position of the vehicle, the receiver should refuse to lock on. In an automatic mode, the receiver will choose to use the station that puts the vehicle near the middle of its map, and it try to change station when the current position of the vehicle is closed to the boundary of the map. In order to speed up the decision, the broadcasted map should have a header to indicate the coverage of the map associated with it.

2.2 Vehicle Positioning

In the proposed system, dead reckoning

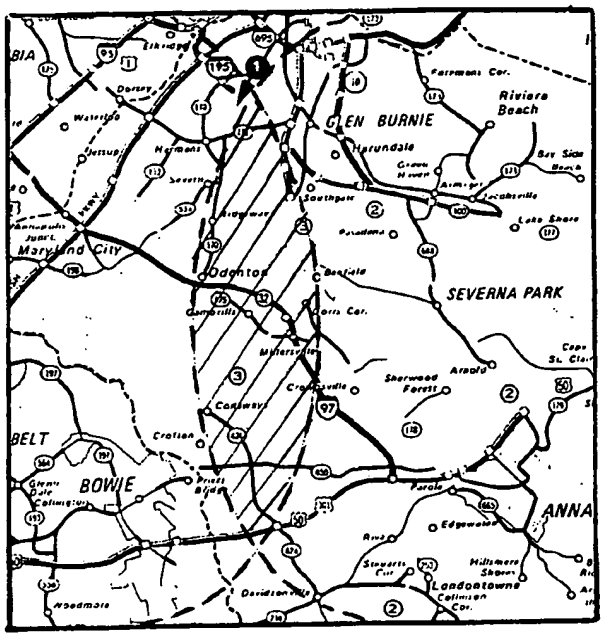


Figure 2: Overlapping between two maps

(odometer and compass) and GPS are used to infer the position of the vehicle. Dead reckoning employs odometer (an accurate one) to measure the distance traveled and compass to keep track of the direction traveled. Knowing the starting location in the map and keeping track all of the segment lengths and directions, the current position in the map can be inferred.

GPS only is actually enough to position the vehicle on the map. The dead reckoning is meant to add precision to the position pointed out by GPS. The GPS is based on a number of satellites currently in orbit around the earth [4,6]. From an altitude of 10,900 nautical miles, a number of NavStar spacecraft continuously transmit navigation signals. Thus, allows unlimited number of users to obtain a precise 3-D position, velocity if necessary in any weather, anywhere anytime on the earth. Each space craft transmits two pseudo random noise spread-spectrum signals at L1 and L2 frequencies. A pseudo-random sequence of binary digits is impressed onto each of the carrier frequencies. This is called precision code (P-code). Another signal, called the clear/acquisition (C/A) code, is quadriphase-modulated with the P-code on either the L1 or L2 signals. The C/A signal

provides a less accurate position fix than the P-code. The encrypted P-Code provides 3-D position information accurate to about 15mm, velocity accurate to 0.10 m/sec and time to an accuracy of several nsec. The key to the system's precision is an atomic clock;

2.3 Fusing Position with Local Map

One important and unique feature proposed here is the dynamic fusion of the GPS coordinates on the digital local map. More specifically, the local map broadcasted by a station is a 2-D array image with new coordinates compatible to GPS ones for a particular geographic region. Thus, the fusion of the GPS coordinates is a very simple task for the car's navigation system.

When a local map includes a traffic problem displayed with a certain color, the car's computer compares continuously the GPS coordinates with the traffic coordinates and inform the driver to use alternative routes before the car will reach the bottle-neck point.

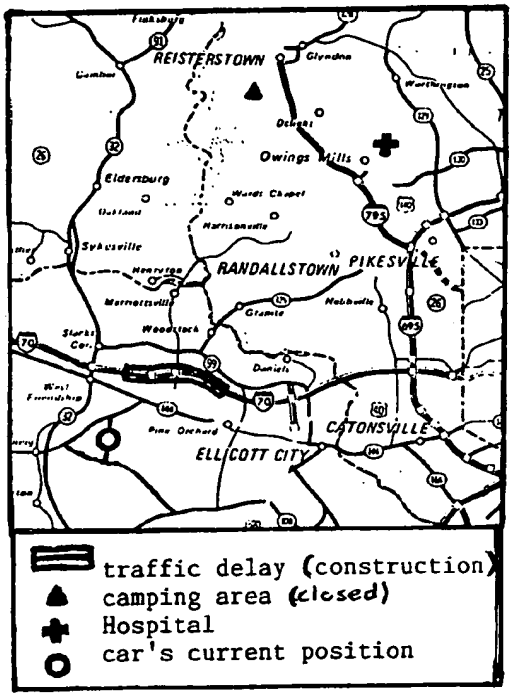


Figure 3: A local map with current information

2.4 Transmission Protocol

The map data transmitted by a station is naturally large, since it contains the map, the traffic statistic, and the location of travel related places along with its information, see visual representation in figure 3. Thus, the data transmission will take a period of time. In this case, a protocol is needed to synchronize the transmission. The map along with its information is transmitted repeatedly as a data package. Data package will be transmitted in within a period of time, with a starting signal and end signal to differentiate one data package from another. This time period (depends on the size of the data) and the protocol (synchronization) for the data transfer between the station and the vehicle, since there is no handshaking between the station and the car's receiver. Thus, the car's receiver has to synchronized itself to the transmitter of the station, by detecting the starting and ending signals. All of these parameters, starting signal, ending signal, transmission speed, data package format, etc, have to be standardized for an effective use.

2.5. The System

2.5.1. Broadcasting Station

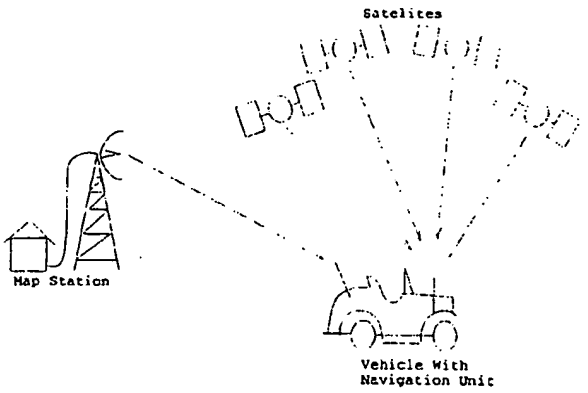
In a broadcasting station there are a map/information editor (operator), a map/information storage/database, a modulator, and broadcasting antenna, see a global figure 4.

2.5.2. The Navigation Unit

The navigation unit consists of a map/info receiver (radio, including demodulator), a map/info storage, a GPS receiver, a positioning system, a map/position fusion unit, a planer/router unit, a display for I/O, and several control buttons, see figure 5.

3. Advantages and Impact

The impact of the methodology proposed here



is significant for the reduction of traffic jams and better distribution of the overall traffic. It will reduce the delays near big sites, save lives with the selection of the shortest traffic path, define more accurate positions of highway accidents by reducing the inconsistent reports produced by officials, provide updated information (recent construction, delays, detours, new facilities, etc) to car drivers not included in CD-ROMs.

Also, it will use traffic statistics indirectly distributed to the traffic routes for efficient selection of alternative traffic paths.

The technology for implementation is already available, and the implementation cost after all of the parameter had been standardized will be low cost.

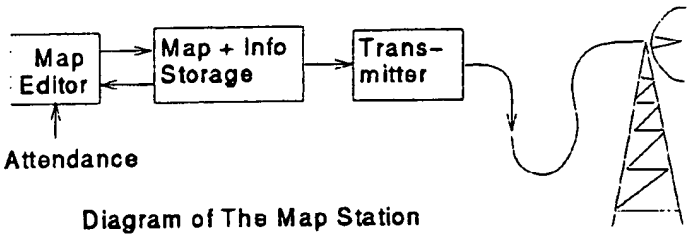


Diagram of The Map Station

Figure 4.

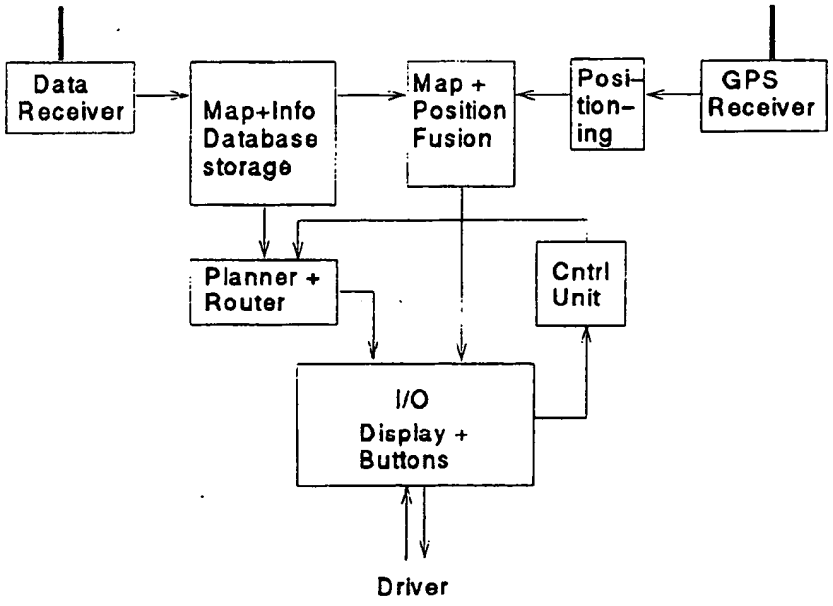


Diagram of The Navigation System

Figure 5.

4. Conclusions

In this paper an efficient, low cost car's navigation methodology was presented, by taking into account the dynamic changes that occur in real traffic environments. The method-system proposed here was based on the fusion of local maps and additional region information (broadcasted by a station) and the GPS coordinates. This method will eliminate the disadvantages provided by CD-ROMs, such as the current status of the traffic delays, constructions, detours, accidents, traffic readjustments, etc occurred in several geographic regions. A navigation system built in a vehicle will receive the local maps and will fuse in them the GPS coordinates in order to locate the vehicle, as light spot, on the map. This approach provides to the driver several choices and sufficient information for a safe, convenient travel with a low cost implementation.

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